ARTICLE VII.

Memoir on the Character and Prospects of the Copper Region of Gibara, and a Sketch of the Geology of the north-east part of the Island of Cuba, by Rich. C. Taylor. Read May 30, 1843.

The writer of the following pages passed a portion of the year 1836 in investigating the Gibara and Holguin Mineral Region, a district, which, prior to that period, was little known to science. Some of his notes relative to Cuba geology, in the form of detached papers, were contributed to the London and Edinburgh Philosophical Magazine; and to Loudon's Magazine of Natural History: and the American Philosophical Society has done him the honour to print in one of their volumes of Transactions, an account of the deposites or veins of mineral pitch or bitumen, denominated *Chappapote*, in the neighbourhood of Havana and Matanzas, and also in the Bay of Havana.

Many details of the geology around Gibara, and in particular those relating to the mineral and savana region south of that port, were reserved for a more elaborate communication, and for some such favourable occasion as the present.

The main difficulty, which at the outset seemed to render the undertaking almost impracticable, was the total absence of a topographical map: nor was it found possible to remedy the deficiency, on the occasion, save by one means—to construct a map for himself, sufficient for geological illustration. With the aid of the few instruments then in his possession, he commenced the framework of his topographical survey, and made the essential observations alone and almost entirely unassisted.

These notes have now, after a long interval, been put together. Upward of a hundred lines and angles of intersection, and considerably more than that number of topographical admeasurements, form the basis of the accompanying reconnoissance. The writer was compelled to abandon the work and to return home, before requiring a sufficient number of points, essential to an adequate triangulation of the area examined. For this there is now no remedy; and he proceeds to make the most of the materials he has acquired. Those who have experienced the toil of such investigations within the tropics; the exposure to enervating heat; and have felt the fatigue consequent on any exertion in the midst of a tropical mountain vegetation,—and that single handed,—will be ready to make all reasonable allowance for the obvious deficiencies of the present communication. All that he

assumes, therefore, in its behalf, is that it suffices for the outline of a geological reconnoissance; that it exhibits sufficiently the position of the most remarkable mountain masses; and that it illustrates the localities of the rock formations, and the direction of the mineral veins within the area submitted to examination.

Of late years, enterprise, at home and abroad, has unfortunately received so severe a check, that no progress has been made in cultivating the really valuable mineral resources of this part of the Island. They remain, therefore, pretty nearly in the state in which they were left by the writer, a few years ago. It is not improbable but that a faithful sketch of what fell under his observation, may have some influence in directing attention to that fruitful source of industry.

The analytical examination of the mineral substances was performed by his associate, Mr. Clemson of this city, who contributed some valuable aid in these investigations.

A copy of this memoir and of the map, and of every essential detail, has been in the hands of a scientific friend, now a resident of this district. He has taken the pains to verify the data upon the spot, which inspires the writer with the greater confidence in making public this communication.

GEOLOGICAL CHARACTER OF THE GIBARA REGION.

On landing at the Port of Gibara, the first rock that we perceive is an ancient coral reef, forming a belt of no great breadth, attaining an elevation of twenty or thirty feet above the sea; and rather more than that above the level of living corals, in the reefs that border the northern coast of this island.

Proceeding south, into the interior, we cross compact white limestones, which are far older than the agglomerated coral limestone we have just quitted.

To these succeed belts and beds of metamorphic rocks, having a magnesian base. Their direction appears to average north-east or east-north-east, but all bear the impress of great change of position, structure and arrangement. As we proceed we perceive rocks allied to diabase, trap, and porphyry, exhibiting additional evidences of disturbance. Then follow a numerous suite of stratified rocks. They consist of varieties of serpentine, ophiolite, metalloide diallage, (euphotide) hypersthene, diorite, schillerspar, feldspar, and amphibole, variously modified and blended. To these may be added ferruginous opal, jasper, jade, chalcedony, quartz, porphyry, calcareous tufa and breccia, diabase or greenstone, and conglomerates composed of fragments of several of these substances. Beds of dark green claystone, and soft dark rocks, modified by heat, alternate with the harder magnesian and hypersthene rocks, and with enormous masses of white metamorphic limestone; the latter of which attains a greater elevation than any other. With the exception of a few partially obliterated corals in the limestone, the rest are wholly devoid of organic remains.

ANTICLINAL AXIS—AND LIMESTONE CHAINS.

In the topographical sketch which was prepared to illustrate this paper, it will be perceived that two principal and two inferior parallel chains of cavernous limestone mountains range along this part of the island, in an east-north-east direction. The first or northern chain comprehends those lofty, isolated, and singularly shaped mountains which are recognised so far at sea: comprehending *El Paramo, La Silla, Cerro Colorado* and *Llavason,* besides some hills of inferior note. One cannot contemplate their remarkable outlines without receiving the impression that the masses of which they are composed, have been thrust up from below. This conclusion is much strengthened on a more particular investigation, when it is discovered that this chain is the centre of a great anticlinal arch. From this axis the whole series of rock formations in the country are tilted in opposite directions. In the area on the north, forming a belt extending to the sea coast, eight or ten miles broad, all the rocks decline at an angle of at least forty-five degrees towards the north. On the south side the axis, and to an equal breadth at least, the strata all dip at an average angle of sixty-five degrees southward, or in the opposite direction to the first.* Of the longitudinal extent of the anticlinal axis we know that it is at least thirty miles, that being the extreme limit of the observations made by the writer.

The general range of the anticlinal axis, of the four limestone chains, of the mineral lodes and of the rock stratification, have a sufficient correspondence in parallelism; being not far from E. N. E. and W. S. W. Now if we apply to a map of Cuba, and protract this course upon it, we perceive that instead of running longitudinally with the island, it traverses it obliquely. The course therefore, of the island being N. 70° W. and that of the axis, &c. being S. 60° W., there is an angle between them of 50°. It is essential to note this, that it might not be supposed that the axis we have thus far traced, followed the prevailing direction of the Island, but rather of a spur from the central mountains. The same course of S. 70° E., if prolonged, follows the central range of the Island of Hayti. If there were no change in the course of the copper lodes, and no deflection in the stratification, within the region under consideration, they would cut out on the south side, not far west of C. de Cruz, which is scarcely probable. It is far more likely that, on reaching the Sienitic region of Holguin, the series is deflected to the west, and may then follow the general direction of the Island. This is proved by following the Gold Lode N. W. of Holguin—which runs N. 55° W.

We were inclined to the belief that the area which lies to the north of the anticlinal axis has undergone a greater metamorphic change than the area to the south. In both instances it appeared that the disturbance and igneous alteration of the rocks were greatest at the parts which are nearest to the anticlinal axis. Another important circumstance

* The details of the admeasurements of this southern dip, at the best ascertained positions, show as follows. At the mines of *Sabana Vieja* 70°.—At those of *Buena Isabela* 63°, 67°—70°—and 73°; at *San Augustin* mine 55°—60°—and 65°.—At *Olivo* mine almost perpendicular. Limestone hills south of *Sabana Vieja,* 50°—55°—60°—75° and 80°.—Limestone ridges on each side of the copper region, generally 60° to 70°.—At *Sao Gibara* 50° to 60°.

We have had fewer opportunities to ascertain the variations in the northern zone; but 45° is the lowest observed angle in that direction.

we could not fail to observe. All the isolated limestone peaks and mountains which range in the direction of the principal chain, are surrounded at their bases by trap, greenstone, or diabase, and by greatly modified rocks.

The next limestone chain, in importance, but the third in succession, is at the distance of five miles south from the first. It embraces the *Cerro alto*, the *Sierra Corolito, Cerro de Gibara* and the *Toro loco* groupe. This pursues the same general parallel as the first chain, and ranges with the great trap and greenstone ridge of *Loma larga*, which stretches five or six miles to the eastward from *Cerro de Gibara*. In elevation this second range is probably little inferior to the first. Its mountains exhibit similar precipitous faces and are very rarely visited; certainly not by any scientific persons.

The fourth chain, at the distance of two miles south from the third, comprises the *Loma verde*, the conical *Sierra pilon*, *Las Palmas*, *Melones*, and three inferior limestone hills; occupying about ten miles in length on our map. The vicinity of these mountains is less changed by igneous causes, than those we first described. The intermediate area of two miles, between the third and fourth limestone ranges, comprehends what may be more especially termed the mineral region of the savanas.

Far to the south-east, at the distance of seven miles from *Sabana Vieja*, rises the single lofty, conical *Tivisial* mountain, whose outline, as seen from that position, has a remarkably volcanic character.

THE SAVANA REGION.

It is scarcely necessary to premise that the term savana implies a sterile elevated range; for the most part clear of wood, except some detached Palmettos, Mahogany trees, Corojo Palms, Aloes, and patches of thorny shrubs, loaded with flowers. The surface is every where strewed with detritus from the adjacent rocks; and is overrun by a coarse, wiry grass, rejected by cattle.

Innumerable small streams, whose beds are nearly dry, for a great part of the year, wind amidst the savanas; and descend towards the sea. The humid places are distinguishable afar by the characteristic luxuriance of their vegetation. The streams are fringed with rich woodland; and flats of alluvial soil, the most prolific, perhaps, in the world, stretch along their margins.

We are constrained to advert to these natural features; for they are not wholly unimportant to the miner. In the first place, he perceives that the extraordinary undulations of the surface, and the interlocking of the ravines, offer great facilities to his operations of mining and draining the mineral lodes. In an economical point of view, he sees that although the mines are seated within areas of absolute barrenness, they are in close proximity to others of surprising fertility; capable of sustaining a dense population connected with his operations. Nothing can be more favourable to him than this happy combination of circumstances.

Whilst taking a rapid sketch of the geology of this district, we enumerated the rocks which occur there. With the exception of the igneous rocks, whose position is, of course generally obscure and unconformable, the whole series is stratified, or at least it bears

evidence of having been originally so. They are extremely variable in structure and composition. Whilst some are compact, crystalline, and abound in metalloide diallage and hypersthene, others are fibrous and magnesian, readily decomposing in the atmosphere. With the serpentines occur also the euphotides. One can rarely traverse the savanas, even for the space of a few hundred yards, without meeting with irregular masses of diabase, amidst the ordinary serpentines. At *Sabana Vieja*, for instance, the prevailing rock is serpentine; one variety of which is soft, talcose, and easily worked in the mining operations. Another variety is much harder; of a dark green colour, accompanied with crystals of diallage of various colours, but most commonly of a bronze metallic lustre. This quality is so abundant here that we not unfrequently apply to it the name of Sabana rock. A third species is so compact as to require blasting, when it is encountered in shafts and adits. Amongst these beds occur others of very hard trap rock, or of diabase; also of quartz and hornblende. Some talcose fibrous beds, with veins of asbestos, occasionally intervene, and accompany the pure serpentine. Bands of metamorphic rocks often intrude. In fact, so variable is the geological composition of this district, that scarcely two cubical yards can be found, which precisely assimilate. An attempt to define these varieties, would extend this article to a wearisome length. Such multitudinous and ever changing characters present themselves, on all sides, that it would be a hopeless task to particularize them. In most of the mines where galleries, and shafts have been driven, this varying character was perceptible at every foot, and indeed, at every inch of progress. A museum might be filled with specimens from a single locality.

WHITE LIMESTONE.

It has already been remarked that the rock which attains the greatest elevation in the Gibara region is the compact modified limestone. Although it may be true that this elevation may be due to an upheaving force or thrusting up from below, yet it seems certain that this rock is contemporaneous with the surrounding savana series. This is clearly exemplified at certain points, a few miles remote from the anticlinal axis; at which points it is seen distinctly interstratified with, and consequently of the same age as, the magnesian rocks.*

As we approach the Port of Gibara from the Bahamas, the aspect of the coast is bold and striking. Mountains of strange forms, and isolated bluffs with precipitous faces; and serrated ridges; elevated saddle-shaped masses, steep and bare of vegetation, and shining white in the sun's rays, range along the coast, at the distance of a few miles inland. When we approach nearer, and pass amidst them, to the undulating savanas in their rear, and note them stretching far away to the east and to the west, we perceive

* It can neither be the lithographic, cavernous "Calcaire de Guisnes" described by Humboldt near Matanzas and Trinidad, containing fossils of the age of the London clay; nor is it the "White Limestone," of Mr. D. la Beehe, in Jamaica, whose fossils are also of the same age as the "Calcaire Grossier." This Calcaire de Guisnes is the same rock which apparently forms, to the eastward, the limestone of Hayti; to the south the white limestone of Jamaica; to the south-west the Calcaire de Caribe in the environs of Cumana; and to the west the arid cavernous limestone which occupies the peninsula of Yucatan.

ourselves surrounded by objects highly attractive by their novelty and by their great geological interest. From the midst of the arid savanas, as well as from the lower wooded plains, arise those lofty detached mountains of compact marble, whose unusual shapes, and whose white, vertical escarpments, contrast strongly with the brown, sunburnt hills of serpentine; and confer such a peculiarity on the contour of the coast; and furnish to the far-off mariner such conspicuous landmarks.

On reaching these mountains, their precipitous cliffs appear to be distinctly striated or fluted, vertically; having resemblance to clusters of enormous columns, hundreds of feet in height. At first we attributed this appearance to the possibility of vertical strata. On a nearer examination no trace of stratification appeared. We saw that this columnar appearance was simply derived from the erosion of the escarpment, into deep vertical grooves. On the mountain of *La Silla*, this phenomenon is beautifully exhibited. When, from its summit, we looked down upon the numerous spurs of this saddle-shaped ridge, and upon its surrounding indented masses, we seemed to perceive an assemblage of groups of enormous crystals of white rock, distributed over a space nearly a mile broad and two miles long; shooting upwards from the dark woods below. From the bases of several other mountains equally characteristic views arise; in the resemblance to snow-white basaltic pillars, clear of vegetation on their sides; except here and there an aloe, or some flowering shrub rooted in a crevice. At a short distance the illusion is equally perfect, when we look towards the jagged outline of the crest, it would seem as if an entire mountain, a thousand feet in height, constitutes one vast group of crystals.

The Gibara river is, in many places, crossed by calcareous bands; and, near the great anticlinal axis, before adverted to, the masses are frequently traversed by a beautiful network of delicate *quartz veins.* They also exhibit evidence of having been greatly shattered, broken up, and distorted. Their fragments have been subsequently re-united by siliceous cement; but their original continuity and parallelism of deposite, are nearly obliterated. In other cases, all traces of stratification have been removed from the now perfectly compact mass.

Two miles to the south of the plantation of *Gibara arriba*, our map shows a couple of nearly circular hills, or great mounds, of compact limestone, in the range of La Silla; apparently surrounded by, or thrust up from beneath, an area of diabase. The summits of these somewhat conical hills, are not altogether solid limestone, but consist of an accumulation of shattered masses of that rock, piled rudely upon each other. The weathered surfaces of these calcareous masses, are worn into deep holes, with intermediate points, somewhat dangerous to walk upon. In this respect it exactly resembles the waterworn limestone and old coral rock, which on the Cuba coast, are now daily subjected to the action of the waves. I may add another instance, more recently observed by me, in the case of the Tully limestone of New York, wherever the surface is exposed to the erosive action of the waves of Cayuga Lake. But in the hills of our first limestone chain, in the great anticlinal axis of Gibara, wherever any vertical escarpment prevails, and even where the sides of the detached masses have steep faces, we observed them furrowed in perpendicular grooves: thus presenting that appearance of columnar arrangement, which we before noticed on a more magnificent scale. This rock is sonorous when struck; reminding us of the musical ringing sound commonly produced by chalk flints. The fracture

is sharply conchoidal; the texture is perfectly compact, and inclined to waxey. It burns into a superior quality of lime. In the absence of more appropriate names, we called these two hills, the Wild Dog hills, because they afforded secure retreats to the numerous wild dogs with which the country is infested.

On the southern borders of Sabana Vieja, corresponding with the fourth limestone chain, appear two other conical hills, which seem to rise up from the midst of the surrounding Savana rock. The metamorphic influence is less observable than in those rocks which are near the anticlinal axis. Here the stratification of the white limestone is distinct and undisturbed, except so far as may be indicated by a flexuous or undulating arrangement of its beds. In the westernmost of these two hills the general dip of the stratification is fifty or sixty degrees, to the S. E. For the most part the beds are thin; some of them contain long, flattened, red, cherty nodules; or the mass is interspersed with seams of flesh-coloured calcareous rock, from two to eight inches thick. The easternmost hill also consists of thin wavey beds; which, along the crest of the ridge, dip as much as seventy-five or eighty degrees to the S. E. In this case, the limestone is mottled with reddish nodules, and interstratified with similarly coloured red seams.

The colour of the Gibara limestones exhibits various gradations, from a pure white. These tints are always extremely delicate; and are cream-coloured, slightly greenish, yellowish, or even pink. In structure this marble is, for the most part, beautifully fine and compact:—too much so, it is said by architects, to admit of its adaptation to external building purposes. But for finished, delicate work, in the interior; and for the ornamental departments of architecture and sculpture, it appears to be well adapted.

Upon the flanks of most of these mountains, between the greenstone and our compact limestone, occur tufaceous deposites; derived, doubtless, from the latter, and brought down by numerous descending springs. This soft tufa invests various substances, and contains beautiful impressions of leaves and vegetable fragments. We have observed this, in particular, near the base of *La Silla*, and in the direction of *Llavason;* where extensive marley tufaceous accumulations attest the disintegration of the neighbouring limestone. Often this tufa envelopes fragments of various rocks, and after consolidation, represents a variety of breccia. The streams of this country, particularly near the anticlinal axis, abound in instances of such aggregations. These, however, must not be confounded with the tufa which is derived from the decomposition of the old coral rocks, near the coast: such, for instance, as that which, near Havana, is used, somewhat extensively, in the making of carbonic acid gas, for the manufactory of soda water.

It is a very prevalent character of the Gibara limestone, that it contains or embraces large masses of carbonate of lime, of comparatively recent origin, enveloping shells. We account for this on the principle that they occupy in the solid form, what were formerly open fissures. This new rock is customarily of a reddish colour, generally quite fetid; and encloses organic substances of which we shall speak hereafter. If the enclosing limestone ever contained organic remains, their forms have been obliterated by the changes of which we have such satisfactory evidence. The honeycombed irregularities of the surface, especially in the limestone of the First Chain, exhibit sharp projecting points, and innumerable round holes, an inch in diameter and two or three inches deep, resembling auger holes.

We have sufficiently adverted to the extensive changes of position and inclination, and the striking modifications visible in the composition of almost every rock we have seen on this quarter of the island. Towards the western part of Cuba, this influence, among many other manifestations, is seen in the injection of liquid petroleum and mineral pitch, not only in the form of veins in the old stratified rocks, but in filling cells within the chalcedony and quartz veins by which those rocks are traversed. In the intermediate area under consideration this modifying influence is displayed in the partial vitrifaction of the serpentine and allied rocks;—in the opalized condition of the materials at the outcrops of its mineral veins;—in the admixture and close proximity of undoubted igneous rocks;—in the conversion of quartz into a species of porcelain;—in the kneading together of the horizontal strata and laminæ, into contorted and fantastic forms in some cases;—in the complete obliteration of these original planes of stratification in others;—in the destruction, with a few exceptions, of all traces of organic forms; and in its conversion from a stratified state to that of a compact mass.

THE LIMESTONE MOUNTAIN OF LA SILLA—OR THE SADDLE.

We shall now proceed with a few details of this remarkable mountain, and, in so doing, our description will not be greatly inapplicable to several others in this first or northern chain. We have only approached it from the north and west, where it presents a precipitous escarpment, whose summit, like that of the Cerro Colorado, or Red Mountain, is attainable only at one or two points. The barometer being injured in the ascent, no admeasurements of altitude, to be relied upon, in the emergency, were undertaken. The principal crest was found to be a sharp ridge; a mere wall of pointed rocks, which descended vertically on both sides. Here then was the keystone, as it were, of that great anticlinal arch, which stretches far away in a W. S. W. direction and its reverse. From its upheaved centre declined the vast series, the innumerable varieties of rocks, at a high angle, northward towards the sea and southward towards the mineral savanas of the interior, which we shall hereafter describe.

THE CAVES OF LA SILLA.

The Gibara rock, apparently the same as has acquired in Western Cuba, and in Jamaica, the name of cavernous limestone, presents, within the mountain of La Silla, some examples of these caverns well worthy of our notice. At the foot of a perpendicular cliff is the entrance to the caves of La Silla. They branch to the right and to the left, so as to form suites of chambers, one beyond the other. The suite which lies on the west or left hand side of the main entrance or vestibule, is three hundred and fifty feet long. Into the eastern range we did not penetrate, on account of the contraction of the entrance, even within a very few years, by the accumulation of recent carbonate of lime upon the walls; or by what is not unaptly termed "growing up." The interior of the first bears a rude resemblance to an ancient Saxon Crypt, with its heavily groined roof and its massy pillars and buttresses, composed of continually augmenting stalactitical matter. This con-

stant tendency to encrust the walls, proportionally contracts the areas of the chambers. Already the entrances to several of them are thus for ever closed. Upon the floors of these caverns are strewed and accumulated to a thickness we had no means of estimating, myriads of dead snail and other shells, intermixed with the dung of thousands of bats. We felt assured that in this brick red mould, to which the bats have, for ages, contributed:—in the countless multitude of dead and decomposing land shells, for which this cave seems the tomb or charnel house; and in the slow, yet certain, conversion of the whole mass into a new and solid crystalline rock, we saw the immediate origin of those beds of shelly and sparry limestone, at first sight so perfectly inexplicable, which we now proceed to describe.

LAND SHELL LIMESTONE.

At numerous points during the ascent to the mountain of La Silla, we observed coarsely crystallized carbonate of lime, of a red tinge, crowded with fossil univalve shells, which at the first glance seemed to resemble the tertiary. We were the more readily led to adopt this hasty opinion, because the observations of Humboldt and De la Beche, in other positions within the tropics, had led us to look out for calcareous formations of no very ancient date. We did not immediately discover the true nature and origin of this fossiliferous lime rock of La Silla. Subsequently we perceived that it there occupied what had once been open spaces, fissures, and even caverns, within the compact ancient limestone of this mountain. Occasionally, it was only a few inches thick. At one point it was from ten to thirty feet in thickness, and fifty feet in breadth; externally visible. The latter occurred—and this is important to notice,—at the height of only fifteen feet below the highest summit of the precipitous ridge. It here consisted of numerous layers, most of which emitted an offensive animal odour, when fractured.

After two or three other visits to La Silla, we traced with facility the extent of several of these shelly deposites. We acquired an insight into their origin: and we became familiar with the process by which they were consolidated. We perceived that these fossilized univalves were, in fact merely contemporaneous with living genera and species:—that they were referrible to *land* shells, such as now every where abound in the mountain. and that crawled beneath our feet; to the number of at least nine or ten species. Their inhabitants, at certain seasons perhaps, are wont to retire into the dark caves and the extensive mountain fissures; and some, probably, wholly existed in those sequestered situations. There the dead and unoccupied shells lie in countless numbers; mixed with that red soil of which we have spoken, as derived from the dung of bats. By the stalagmitical process, going on in the caves, in their walls and floors, the shells and other substances, fortuitously within its influence, become enveloped in compact and crystalline carbonate of lime, resembling a far more ancient rock. The operations of infiltration and consolidation, and the enclosing of multitudes of shells, is seen uniformly proceeding, until fissures, and caverns, and irregularities, are alike filled up, and until, finally, the newer limestone, overflows the surface of the older.

We were, at times, when examining this, very recent, formation, reminded of the fetid

osseous breccia of Gibraltar. We even here met with fragments of bones; and it did not appear difficult or improper to refer those animal remains, enclosed in this modern limestone, to the *Hutia*, or large native Indian rat, which attains nearly to the size of the American raccoon. This animal still abounds in the woods, and amidst these mountains of Cuba; and we actually saw them, in abundance, living on the very site where we recognised their partially fossilized remains; and inhabiting the rocks wherein their bones are thus beautifully preserved, and perpetually entombed.

It appears almost incredible that the testacea should accumulate in such vast numbers; sufficient, indeed, to form, with the aid of other accompaniments, distinct stratified masses within the mountain. We know that other organic remains, besides those which we have mentioned as the most conspicuous, have contributed to swell and to vary the amount. We well know that these same caverns are occasionally, if not constantly, tenanted by other inhabitants, than such as we have named:—by iguans and lizards; by frogs of numerous specimens; occasionally by land crabs;—by the large *Majas*, the chicken snake of Cuba, ten feet long; by the wild hog and dog of the country; without mentioning the innumerable numbers of the insect tribes; the scorpions, the tarantulas, and a host of others. We must not forget how singularly adapted, beyond any other perhaps on the globe, are the climate and soil, and vegetation, and other favouring circumstances, of this island, to the production, the maintenance, and the multiplication of animal and insect life; especially in solitudes like those of the mountains of *La Silla* and *El Paramo*. Is it, therefore, remarkable, that in turn the relics of all these animals should be enveloped in stalagmitical matter, and should form a rock which is characterized by such a singular assemblage of organic exuvia? But having witnessed in the caves of La Silla the myriads there congregated, we were at no loss to perceive that these dead shells, and occasionally other matters, intermixed with the red soil, and undergoing the unceasing process of consolidation, by infiltration of carbonate of lime, would at no very distant period, assume the substance of a solid fossiliferous marble, such as in fact we saw abundantly elsewhere.

There yet remains an additional fact to be adverted to; and it is an extremely interesting one. Amongst the land shells, were observed, occasionally, some univalves that were unquestionably *marine*. This fact had, originally, greatly contributed to our perplexity. It was an enigma not to be solved at a glance.

But the mystery *was* cleared up, when we discovered that the active and real transporting agents, in this case, were the *soldier crabs*, which frequent the solitary places, and which use the littoral shells for their temporary residences. Numerous individuals of the genus *Pagurus*, at certain seasons, resort to the sea-shore; and they are often seen, in great numbers on their travels. They return from their pilgrimage, each dragging the deserted shell of some marine univalve; for many a weary mile, over the sands and the wilderness; over swamps, and the most rugged rocks. Thus, like the pilgrims of the olden time, each bearing his shell, to denote the character, and to indicate the extent, of his wanderings, they proceed mile after mile, into the interior; traversing dense woods and climbing the highest and steepest mountains. At the distance of eight or ten miles from the nearest sea beach, we trace them up to the very crests of the most precipitous escarpments of La Silla: hundreds of feet above the ocean. Finally, when the habitation,

to seek which—impelled by a mysterious instinct,—the animal has wandered and toiled so far, and has encountered so many perils,—becomes too circumscribed for its accommodation, he is constrained to desert it for some more suitable shell; leaving the discarded one, amidst the land shells and the animal exuviæ of the caverns, there to form a new rock, and a geological puzzle, and to furnish materials for the elaborate speculations of some future savan.

MARINE UNIVALVES SEEN ON LA SILLA.

R. C. Taylor.

Trochus ———
T ———
T ———
Turbo muricatus.
T ———
T ———
Littorina ———
Monadonta.
Probably some other species, unobserved.

LAND SHELLS OF LA SILLA.

Examined by Isaac Lea, Esq.

Cyclostoma sulcata, ...	Lamarck.
Pupa Murnia, ...	Lam.
Caracolla marginata, ...	Lam.
Caracolla ———	(?)
Helix microstoma, ...	Lam.
Helicogena auricoma.	
Helix muscarium, ...	Lea.
Helix purpuragula, ...	Lea.
Clausitilia, ...	(?)

ADMIXTURE OF FLUVIATILE, MARINE AND LAND SHELLS.

The shores of the bays of the northern coast of Cuba furnish interesting examples of the commingling of shells, the occupants of which had respectively lived under very different circumstances. Several streams, for instance, empty into the Bay of Gibara, and bring down, during floods, vast numbers of land shells from the high lands. With these are numerous small fresh water univalves, the *Neritinia virginea* of Lamarck. No bivalves were observed in these rivers. Were any geological change to take place, by which these accumulated exuviæ of the sea, the rivers, and the land, would be consolidated, as the organic matters are at this moment subjected to in the mountain caves, and at some remote period be investigated by a naturalist, he would see here but a repetition of the phenomena of supposed estuary deposites, which have more than one parallel in remote parts of the globe.

CORAL ROCKS AND REEFS OF DIFFERENT AGES.

In the calcareous rocks of Cuba we have seen nothing to countenance an hypothesis of a gradual passage, from the submerged reefs of living corals that encircle the island, to the older fragmentary coral rock that fringes the coast, at some twenty or thirty feet above the sea: and still less to the metamorphic limestone of the interior. We are able, in more than one position on the coast, to see, very distinctly, this compact limestone dipping below the old coral rock, at an angle of forty-five degrees, northward. Beyond the latter extends the reef of living corals; ranging in advance of the coast line, so as to leave an intermediate space of shoal water, called the *Baxo*, a quarter of a mile or so in breadth, and abounding with fish.* At all times, but particularly when there is a swell to windward, the surf breaks with violence upon this reef, so as to be heard many miles inland. At low water some of the corals are level with the surface, and others are suffi-

* Loudon's Magazine of Natural History, Vol. IX., p. 449.

ciently below it to admit of the passage of a boat, when steered with caution. Their arrangement is not unworthy of notice, being so disposed as to offer much less resistance to the landward motion of the swell, than would be anticipated. They present, not a solid surface, a vertical obstacle, as has been often stated, but a partial obstruction to the water which rushes through or between numerous coral groups. This is owing to their being arranged somewhat in rows or tiers; not parallel with the reef, but disposed at right angles to it: and admitting the broken waves to pass amidst them, into shoal water. Thus, for years, perhaps for ages, the thundering surf may fall harmlessly upon and amongst these beautiful productions of nature. The effect of the barrier, according to this arrangement, is far more effective and permanent, as a breakwater, than if it had presented the solid, abrupt wall which a reef is commonly represented to be.

Bordering the beach or shore, next the Baxo, is the older reef, furnishing ample evidence of a change of level. This, for awhile, appears as a low perpendicular cliff. It then passes obliquely inland, to westward. Between it and the present beach is now a ridge of low sand-hills, which are thickly covered with bushes, such as the wild fig, the cocoa plum, the sea grape, and a few aloes, palmettos and creeping shrubs. Like the older limestones, this rock is deeply honeycombed, and contains large detached meandrina, madrepores, porites, caryophillia, millepora, astreæ and others; intermingled abundantly with spines of echinites and well preserved, but colourless, shells. In this old coral rock we notice extensive fissures, running sometimes many hundred feet, parallel with the coast line. These fractures may have resulted from the same cause which heaved up the old reef to its present elevation; and then again the latter may have been due to, or influenced by, the movement which, at a distant day, threw the entire mass of substrata into its inclined position, as we now see them. Coral likewise occurs at a much greater elevation on the plains of the interior. Similar phenomena occur on the shores of the island of Jamaica.*

Before we quit the subject of coral reefs, in these latitudes, we may make mention of that remarkable chain of keys, which stretches seemingly in a line, parallel with the north coast of Cuba. These *Cayos*, whose numbers seem interminable, are for the most part, covered with a dark vegetation. Some of them are a mile or two long; others are much smaller, and the trees, by which they are covered, seem to rise out of the sea. Groups, and clumps, and groves of trees, appear as if growing in the water. Occasionally a single tree appears the solitary occupier of its own little island.† From the *Cruz del padre* to the *Punta Icacos*, and still further west, is an almost uninterrupted chain of wooded keys. It occurs at the distance of a few miles from the main land, to which it seems an important protection; at the same time affords the finest fishing grounds, of which the aboriginal Indians well knew the value.

THE MINERAL REGION OF GIBARA.—COPPER.

Discovery of Copper Lodes.—Previous to the year 1830 the existence of copper lodes on the north-east side of Cuba was unknown. They were first discovered in the savanas,

* De la Beche, Transactions of the Geological Society of London, Vol. II., part 12.

† On the old Spanish maps this group is named the *Jardin del Rey*.

during an ineffectual search for gold: and the denouncement of *San Fernando* was then commenced to be worked as a copper mine. Several others were soon after discovered; and legal possession of them was secured, according to the usual Spanish forms, to the proprietors, by authority of the local government. Among the earliest of these was the mine of *San Augustin*, followed by the *Buena Isabela*, in 1835. Stimulated by the success which attended the working of the Cobre mines, to the south, the mineral researches were here prosecuted with activity, and not a savana in our district escaped a strict exploration. The principal copper lode at *Sabana Vieja* was discovered in 1835. Careful examination was made of this denouncement in the following year, and the outcrops of eight copper lodes were traced, within the breadth of a few yards. Of all these we shall shortly speak; but, necessarily, with brevity.

Character of the Copper Lodes.—It has been stated that the mineral veins of this district occur in stratified rocks, the most prevalent of which is serpentine. We have shown that these lodes were contemporaneous with those formations: that is to say, they do not traverse any rocks, but are interstratified with them. Wheresoever our examinations extended, we found that these lodes have regular walls, containing much silicate and carbonate of magnesia; and having polished sides or surfaces. Further, we demonstrated that these copper lodes maintain nearly uniform directions, parallelism, and inclinations, that is to say, the prevailing course is about E. N. E., and the average dip to the south is about sixty-five degrees. As is usual with cupriferous veins, the surface ores, comprising under that head those within fifty or eighty feet below the outcrop, materially differ from the mineral matter at a greater depth. The most prominent varieties of these are the silicates, the carbonates, the oxides, and the sulphurets. Native copper is not unfrequent; but not lower than thirty yards from the outcrop. In the mine of *San Fernando* it occurs in masses of from ten to two hundred or more pounds' weight.

San Fernando.—This mine has heretofore been worked upon the old Mexican system, if system that can be called, which consists of an intricate labyrinth of shafts, slopes, drifts, and holes; winding in most inexplicable confusion, without reference to ventilation or drainage. Subsequently, under better advice, the lode has been intersected by an adit. The ore is a sulphuret, of a dark bronze green, inclining to a bluish gray colour, rich in copper, and intermixed with excellent gray and vitreous copper.*

Socorro, discovered in 1831, and *San Antonio:* the latter has a good lode of rich ore.† *San Juan*, and *Mina Innocentes:* all these have Spanish owners, and have made very little progress.

Olivo.—A Boston undertaking. Its adit was commenced in 1836; a good lode struck in 1837, at two hundred and forty feet below the summit of the savana. The magnesian ground in which this lode occurs is soft and favourable for mining.

San Augustin.—An American undertaking. The mine is eleven miles from the *Embarcadero* or landing place of the Gibara river. Course of the lode E. N. E.—dip 60° to

* Yielding 33.60 per cent. T. G. Clemson. Weaker surface ore below an average 13.56.

† Varying from twenty-three to twenty-seven per cent. of copper.

65° to S., of very promising character; the outcrop ore being the richest in the district.* Three feet thick in the shaft, at forty-six feet depth.

Prosperidad,—Santa Isabel,—San Nicholas.—Separate lodes included in the last denouncement.

Perseverancia.—An American denouncement. A shaft on the lode gave good ore at fifty feet depth.† A second lode is included in this area.

Buena Isabela.—Twelve miles from the Embarcadero. Course E. N. E., along a ridge. A thousand feet of work done in shafts and levels. Three feet thick of solid ore, at ninety feet depth, raised in masses of fifty and one hundred pounds weight; and one mass of three hundred and eight pounds, part of a block of more than a thousand weight.‡ Two smaller lodes occur near. A Philadelphia concern.

Loma de los tibis.—Opposite to *Cerro alto.* But little work done here.

Sabana Vieja.—An American and English undertaking. Possession given by the governor in 1836. It is twelve miles from the Embarcadero, which is one and a half mile from Gibara Bay, and four and a half to the point or town. Eight copper lodes have been defined within this denouncement; and four others are but partially traced. Course of the lodes, with slight variations, N. 56° E., dipping 60° to 70° to S. In some places the outcrop of lode No. 1, is twenty feet and at another point is thirty feet wide.§ No. 2, is six feet between the walls, good bronze-coloured sulphuret. No. 5, lode four or five feet between the walls—rich carbonate, silicate and red oxide or tile ore, in masses attaining to seven hundred pounds weight.

Traces of other copper lodes occur at *Loma larga, Higal, Loma larga de la Palma, Llavason, Sao Rabon, Saoito de los Ranchos,* and several other places.

Chrome Ore—Occurs in prolonged masses, rather than in veins, in several places in the serpentine region; generally in connexion with copper lodes. A large quantity of this ore has recently been mined and shipped to Baltimore; and some has been manufactured on trial in Philadelphia. These metalliferous beds occur on both sides of the third limestone chain.

Iron Ore.—At *Rabon* a very large vein of compact black iron ore.

Magnetic Iron Sand.—Abundant at *Loma larga.*

GOLD.

Auriferous sands and beds.—The quartzose rocks, the quartz veins, the alluvium, and the river sands, around the City of *Holguin,* have long been known to contain gold,

* Four assays, T. G. C.—34.00—23.30—51.60—34.70—16.40—per ct. of copper. One assay J. G. T.—27.54 per ct.

† Ore at bottom of the shaft 26.40—per cent.—T. G. C. Copper.

‡ Six assays, T. G. C.—15.50—14.80—7.10—22.40—27.20—9.40—and six per cent. (S.)

§ Seven assays of lode No. 1.—T. G. C.—8.20—10.30—11.50—20.00—25.40—37.64—32.00 per cent.
Four assays of lode No. 2.—36.50—39.50—16.40—9.20—per cent. copper.
Eight other assays of No. 2.—T. G. C.—14.20—5.70—15.40—17.50—13.00—14.90—23.30 and 13.50 per cent.
Five assays of lode No. 5.—T. G. C.—22.80—34.00—25.40—18.20—20.00 per cent.
Lode No. 7.—T. G. C.—13.20 per cent. Another lode—19.40 per cent.

which has been collected by the simple process of pan washing, but no important works have been ever undertaken, on an efficient scale, for obtaining the precious metal. Certain quartz veins here, contain an amount of gold which would be thought very rich, and eagerly worked in Europe: but the attempt to work these expensive rock veins has, for the present been abandoned. The late investigations into this matter have fully pointed out the sources whence the auriferous sands are derived. It is in the soft fragmentary beds, where the gangue consists of a deposite of miscellaneous rocky and ochreous matter, in a comminuted form, that the more recent researches have been applied.

San Juan Bautista Gold Mine—Is situated in the *Partido* of *Guago, Balis*, five miles north-west of Holguin. At the surface this seam, or vein, for it appears to have regular walls, is four feet and a half wide; improving as it descends, and the ore resembles the *Jacotinga* of *Gongo Soco*, in Brazil. Like the mineral country nearer Gibara, its surface is undulating; diversified with patches of savanas and tracts of rich wood land; the mine being situated within the latter. The neighbourhood is intersected by numerous rivulets, capable of supplying the water for dressing the auriferous ores. We have received recent details of this undertaking, both from the proprietor and from one who devoted several days to its investigation.

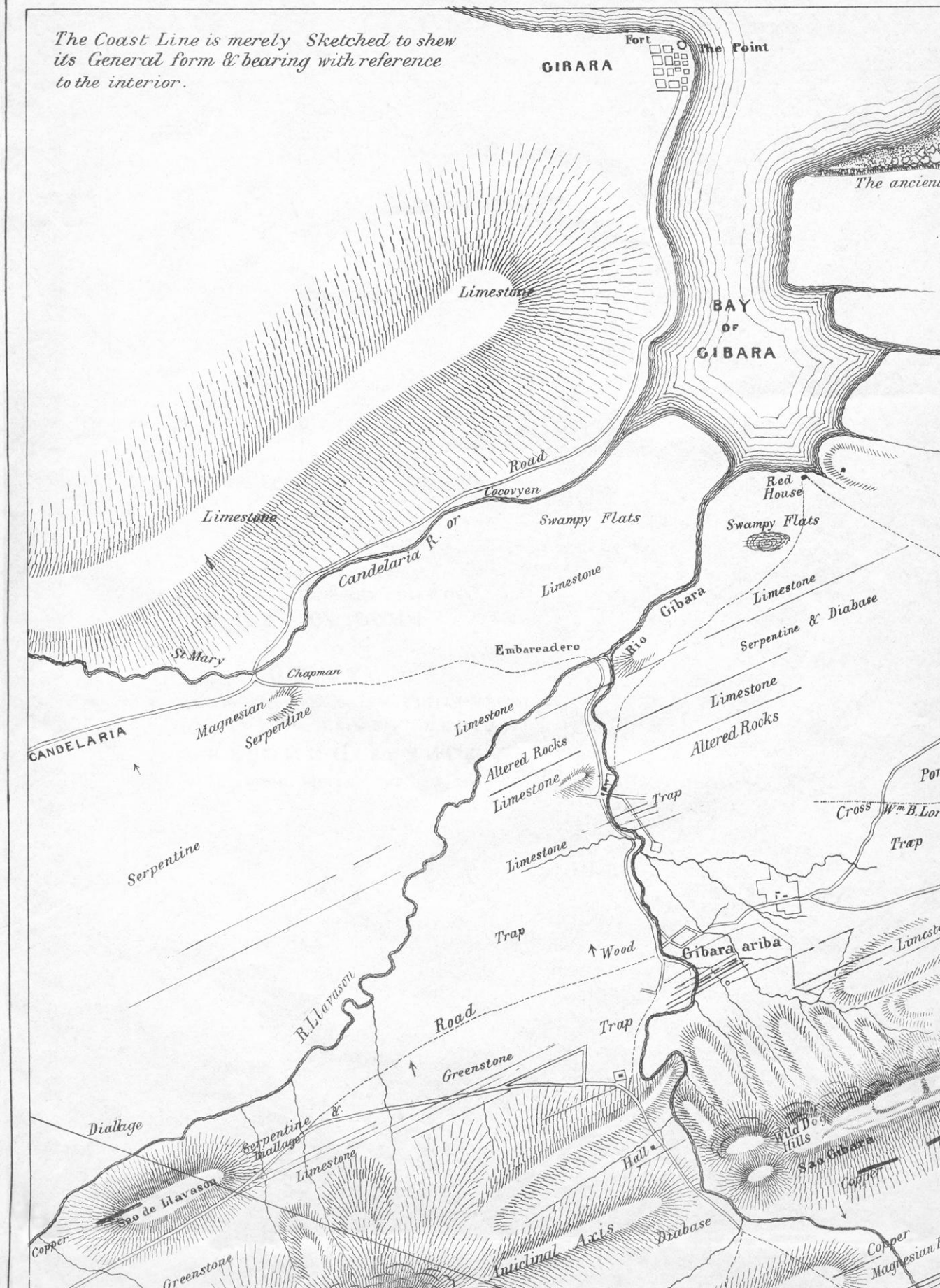
The auriferous vein bears north 55° west, dipping to north-east, at about an angle of 45°. It is composed of a friable, brown and red ochreous earth; intermixed with small quartzose fragments: between walls of magnesian rock, and decomposing schistose rock; in fact corresponding with the savana rocks noticed elsewhere. Very little gold can be detected by the unassisted eye. By an imperfect process more than four ounces of gold were obtained from a ton of this ore, worth therefore about seventy dollars per ton of ore. Large as this result certainly is, it is fully confirmed by assays made subsequently in Philadelphia, and by another made in London.

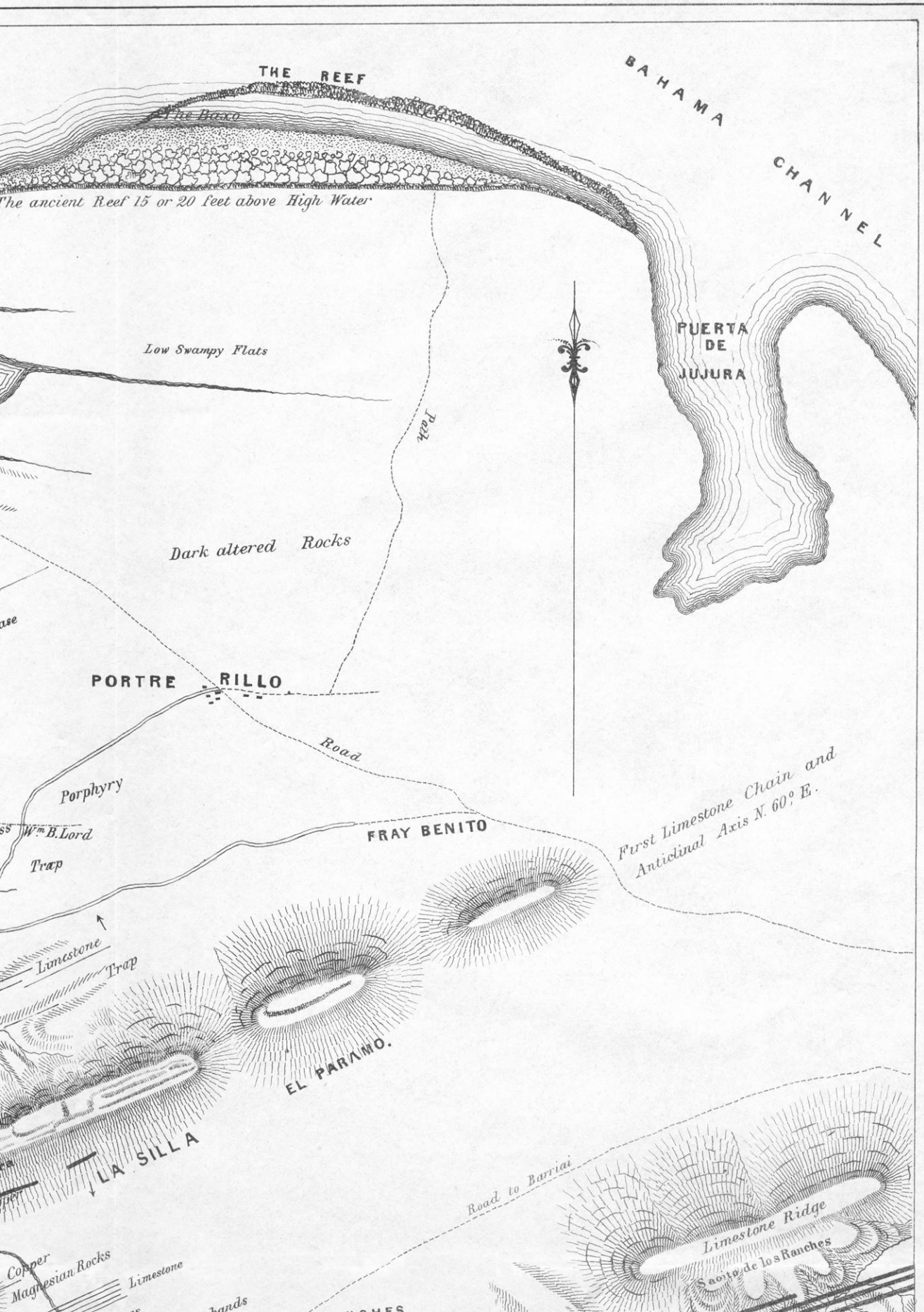
Professor Booth found that the metallic matter resulting from the experiment consisted of at least two-thirds or three-fourths of gold, united with a white metal, probably iridium or osmium, which was insoluble in nitro-muriatic acid.

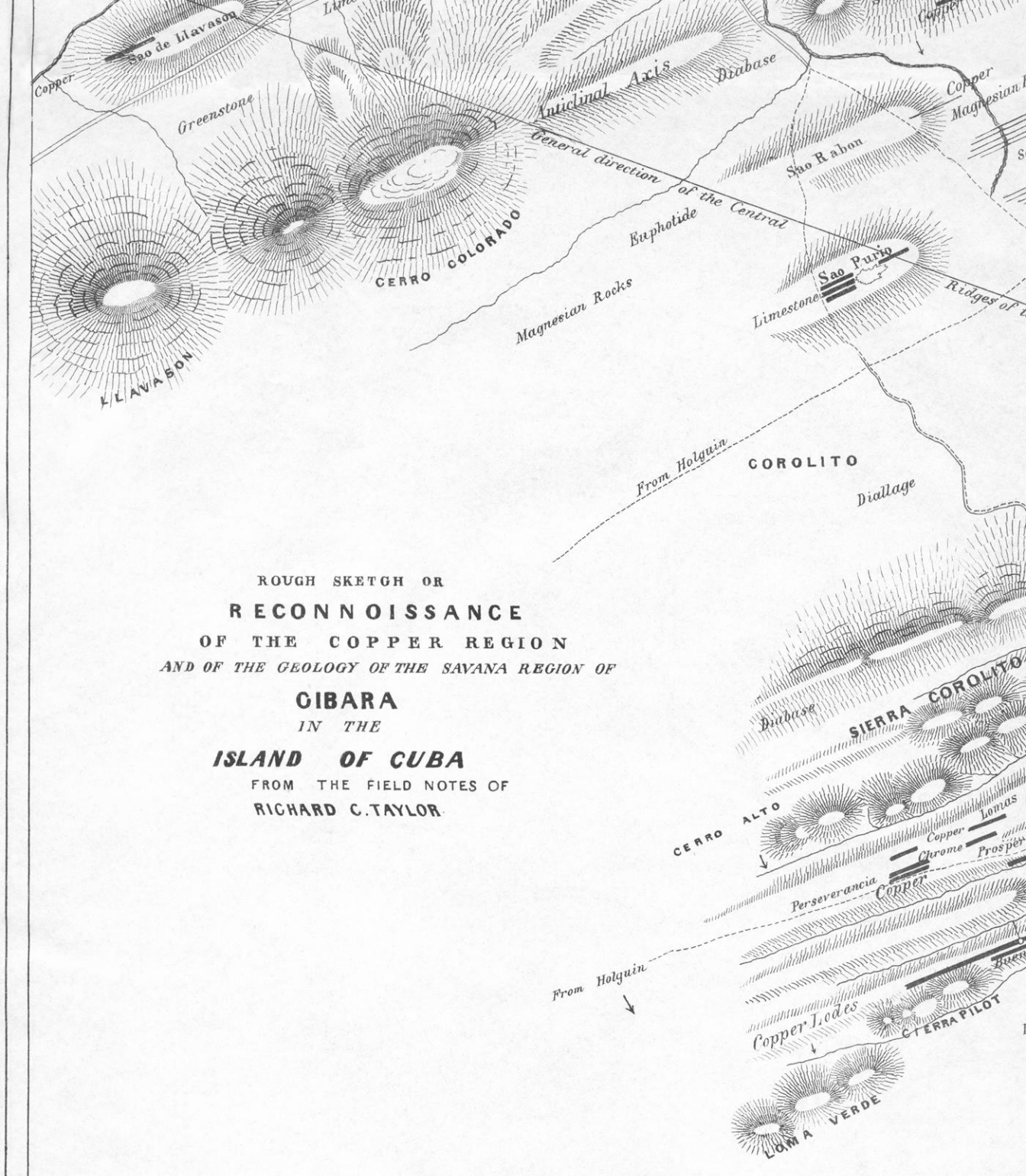
Portions of ore analyzed in Cuba produced three to five ounces of gold per ton of ore. Three other assays in Philadelphia showed the presence of more than five ounces per ton. At present all operations are suspended, at the mine.

CONCLUSION.

It is time to bring this article to a close. The geological character of this region, and the value of its ores, have been detailed as minutely as our limits permit. The field is indeed a promising one; and there is small risk in predicting, that the mineral ores, of which we have made but brief mention, will, from the moment of putting the mines into operation, add immensely to the already abundant resources of this remarkable island. We think it will then appear that industry and skill will be as amply remunerated at Gibara as at Cobre; and judging from the past, it seems very probable that these undertakings are now only awaiting the resources, the capital and the enterprise of Englishmen and Americans, rather than of native adventurers.


The Coast Line is merely Sketched to shew its General form & bearing with reference to the interior.
Fort
The Point
GIBARA
The ancien
BAY OF GIBARA
Limestone
Road
Cocoyyen
Red House
Limestone
Candelaria R. or
Swampy Flats
Swampy Flats
Limestone
Rio Gibara
Limestone
Serpentine & Diabase
St Mary
Embareadero
Chapman
Magnesian
Serpentine
CANDELARIA
Limestone
Altered Rocks
Limestone
Altered Rocks
Trap
Cross
Wm B. Lor
Trap
Serpentine
Limestone
Trap
Wood
Gibara ariba
R. Llavaseu
Road
Trap
Greenstone
Dialkage
Serpentine & Diallage
Limestone
Wild Dog Hills
Sao Gibara
Hall
Sao de Llavaseu
Copper
Inticlinal Axis
Diabase
Copper
Greenstone


THE REEF
The Boxo
The ancient Reef 15 or 20 feet above High Water
BAHAMA CHANNEL
PUERTA DE JUJURA
Low Swampy Flats
Path
Dark altered Rocks
PORTRE RILLO
Road
Porphyry
Wm B. Lord
Trap
FRAY BENITO
First Limestone Chain and Anticlinal Axis N. 60° E.
Limestone
Trap
EL PARAMO.
LA SILLA
Road to Barriai
Copper
Magnesian Rocks
Limestone
Limestone Ridge
Sanito de los Ranches



ROUGH SKETCH OR

RECONNOISSANCE

OF THE COPPER REGION

AND OF THE GEOLOGY OF THE SAVANA REGION OF

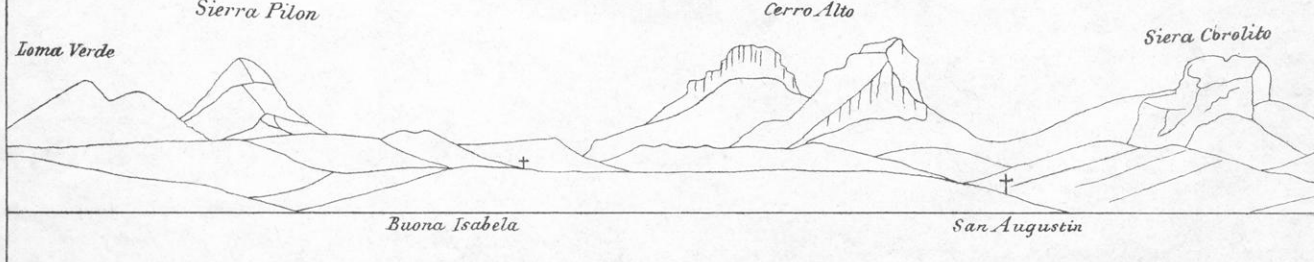
CIBARA

IN THE

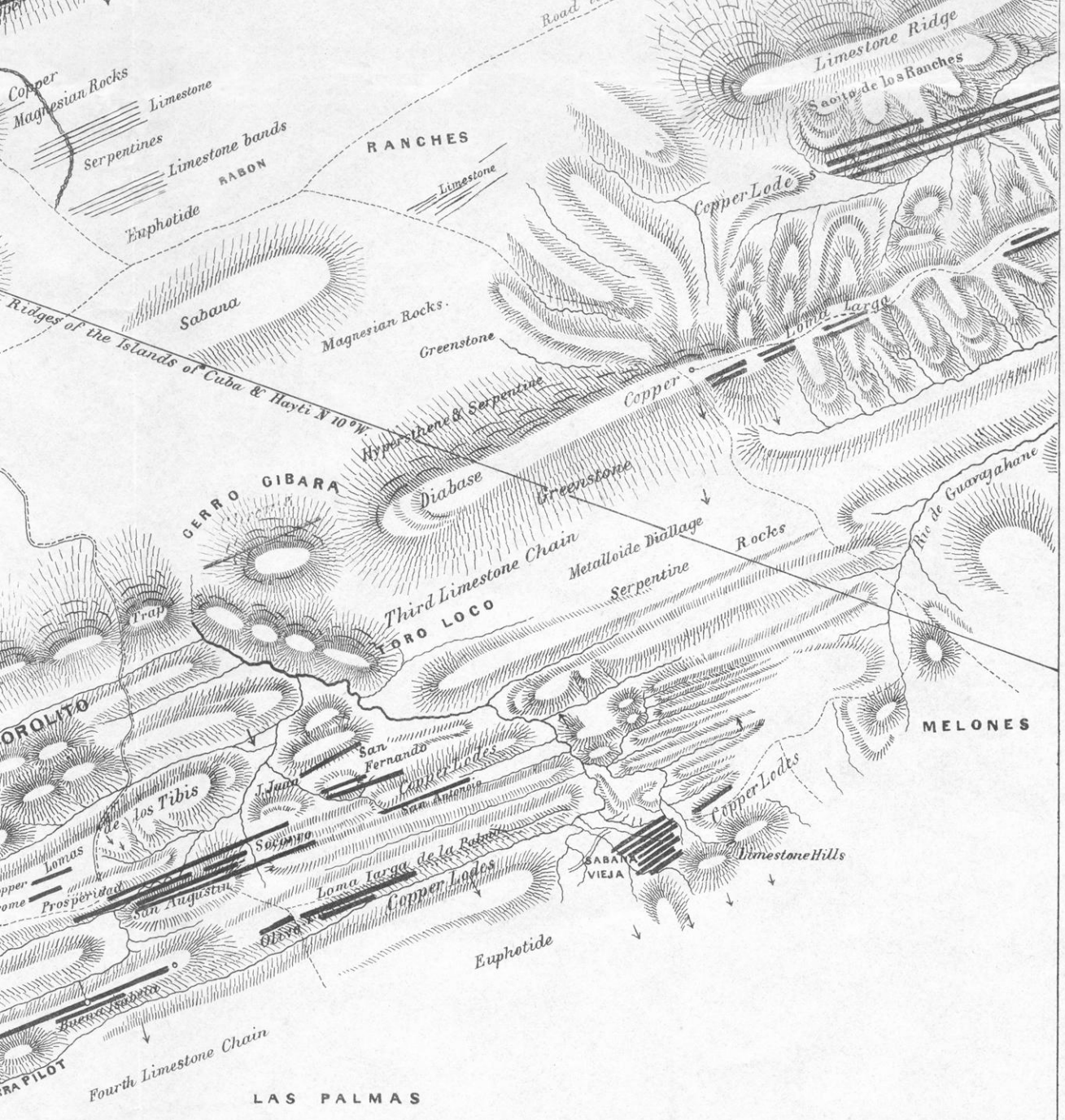
ISLAND OF CUBA

FROM THE FIELD NOTES OF

RICHARD C. TAYLOR.

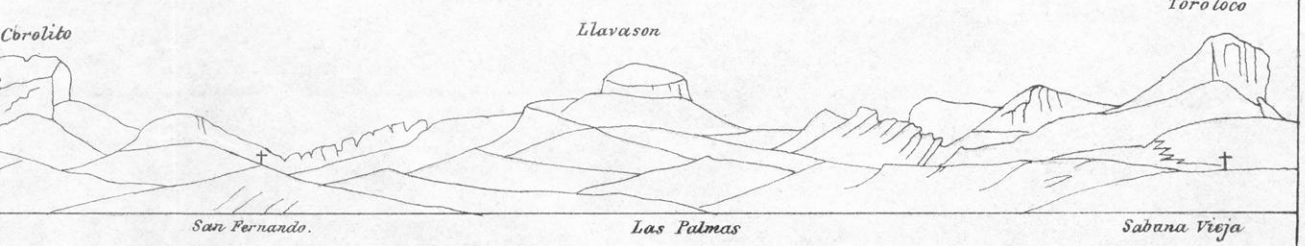


View of the Limestone Mountains in the



Scale One Inch to a Mile

1 2 3 4 m



in the Copper Region from Saban Vieja.

Lith of Sindair 79 S. Third St. Ph.